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## The very high energy $\gamma$ -ray view of the Galactic Centre as of early 2010

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**Abstract.** Progress in the Imaging Atmospheric Cherenkov Technique has enabled first sensitive observations of the innermost few 100 pc of the Milky Way in Very High Energy (VHE;  $> 100$  GeV)  $\gamma$ -rays. Observations by the H.E.S.S. instrument deliver the at date most precise data on this peculiar region, and provide an interesting view onto the acceleration and propagation of energetic particles near the Galactic Centre. Besides two point-like sources – one coincident with the supermassive black hole (SMBH) Sgr A\* – diffuse VHE emission has been discovered within a  $1^\circ$  region around the center. The current VHE  $\gamma$ -ray view of the region is reviewed, and possible counterparts of the  $\gamma$ -ray sources and the origin of the diffuse emission are discussed.

### 1. Introduction

During the last decades, the quality of astronomical data from the Galactic Center (GC) region has increased dramatically. Nowadays, the GC is routinely monitored at radio, infrared, X-ray, and hard X-ray/soft  $\gamma$ -ray energies, and the distribution of dust and atomic and molecular material is surveyed with increasing accuracy. Altogether, these efforts provide a rich multi-wavelength data set of this unique and complex region of the sky, which – due to its proximity to Earth – is an ideal laboratory for investigating the astrophysics of galactic nuclei in general.

The radio picture (LaRosa et al. 2000) of the inner few 100 pc around the gravitational centre reveals numerous sources of non-thermal radiation, most probably caused by synchrotron radiation of relativistic electrons. Particle acceleration to supra-thermal energies is therefore believed to take place at the GC, possibly to a few 10 TeV and beyond. Therefore, this region is a prime target for observations at very high energies, since particles of TeV energy, upon interacting with background photons or molecular material, produce  $\gamma$ -rays in the VHE range. These  $\gamma$ -rays, which pass the GC dust torus and Galactic magnetic fields unaffected, are an excellent tracer for sites of particle acceleration to highest energies.

The VHE  $\gamma$ -ray flux arriving at Earth from typical sources is low. From the direction of the GC point source, a fairly strong  $\gamma$ -ray emitter, a flux well below  $1 \text{ m}^{-2} \text{ yr}^{-1}$  is recorded for  $\gamma$ -rays with energies above 1 TeV. However, the a large detection area available to ground-based VHE  $\gamma$ -ray instruments guarantees good  $\gamma$ -ray statistics, given typical observation times of 1-50 hours. Although VHE  $\gamma$ -rays are efficiently absorbed in the atmosphere, they can be

detected on ground by means of the Cherenkov light of the relativistic air shower particles that are produced in the absorption process (see, e.g., Aharonian et al. 2008, for a recent review). The light pool covers an area of about  $50.000 \text{ m}^2$  on the ground, and instruments like H.E.S.S., MAGIC, VERITAS, and Cangaroo-III use (arrays of) large mirror telescopes to image the Cherenkov light onto sensitive segmented cameras. Detection of VHE  $\gamma$ -rays suffers from background caused by the much more numerous charged cosmic rays impinging Earth's atmosphere. This background can, however, be efficiently suppressed by stereoscopic observation and analysis of the shape of the recorded images. During the last years, Imaging Atmospheric Cherenkov Telescopes (IACTs) opened up a new observational window to the universe: more than 80 VHE  $\gamma$ -ray sources – both Galactic and extragalactic – have been discovered since then, and at least 6 source classes identified (Hinton & Hofmann 2009).

The H.E.S.S. instrument provides the at date best sensitivity for GC observations. The telescope array consists of four 13 m diameter IACTs, located in the Khomas Highlands of Namibia, roughly  $23^\circ$  south of the equator, where the GC culminates close to zenith during the summer months, providing ideal observation conditions. With its  $\sim 5^\circ$  field-of-view H.E.S.S. is able to observe a  $\sim 600 \text{ pc}$  region around the GC with a single pointing of the instrument (assuming a distance to the GC of 8 kpc). Besides strong VHE point-source emission from the direction of Sgr A\* (discussed in sections 2. and 3.), H.E.S.S. detected  $\gamma$ -rays from a pulsar wind nebula (PWN) inside the shell of G 0.9+0.1, a well-known supernova remnant. A comprehensive discussion about G 0.9+0.1 is beyond the scope of this report. Details can be found in Aharonian et al. (2005). Besides the two point sources, H.E.S.S. discovered diffuse VHE emission along the Galactic Centre ridge, correlated with the distribution of molecular clouds in a region of diameter  $\sim 300 \text{ pc}$  around the GC. This diffuse emission and its implications are discussed in section 4.

## 2. Discovery of a strong VHE point source at the GC

Given the importance of the GC as a possible multi-TeV particle accelerator, the region was in the focus of IACTs since the early days of this detection technique. It took, however, until 2004 that a VHE  $\gamma$ -ray signal was detected from the GC by three instruments almost simultaneously (Tsuchiya et al. 2004; Kosack et al. 2004; Aharonian et al. 2004). First results were, however, at odds with one another: while the experiments agreed that the emission was point-like, and no significant flux variability was detected from the source, there was disagreement on the power-law spectral indexes and flux normalisations of the energy spectra measured. The Cangaroo-II instrument reported a  $10 \sigma$  detection above 250 GeV and a very steep spectrum, with an index of  $4.6 \pm 0.5$  (Tsuchiya et al. 2004) and a flux normalisation at 1 TeV of about  $2.7 \times 10^{-12} \text{ cm}^{-2} \text{ s}^{-1} \text{ TeV}^{-1}$ . The Whipple instrument detected the GC with a marginal significance of  $3.7 \sigma$  above the background. The integral  $\gamma$ -ray flux reported was  $(1.6 \pm 0.5_{\text{stat}} \pm 0.3_{\text{sys}}) \times 10^{-12} \text{ cm}^{-2} \text{ s}^{-1}$  above 2.8 TeV, roughly two orders of magnitude larger than the flux measured by Cangaroo-II at these energies.

17 hours of observations during 2003 with two telescopes of the partially completed H.E.S.S. array resulted in two independent data sets and two clear

detections of the GC source (with significances above the background of  $6.1\sigma$  and  $9.2\sigma$ ), henceforth called HESS J1745-290 (Aharonian et al. 2004). The energy spectra of these two measurements were compatible, and hard spectral indexes were reported. However, the results were significantly different from those of Whipple and Cangaroo-II both in terms of spectral index and flux normalisation. 49 hours of follow-up observations carried out in 2004 with the completed H.E.S.S. array confirmed, however, the early H.E.S.S. results: from a power-law fit of the 2004 data, a photon index of  $\Gamma = 2.25 \pm 0.04_{\text{stat}} \pm 0.10_{\text{sys}}$  and an integral flux above 1 TeV of  $(1.87 \pm 0.10_{\text{stat}} \pm 0.30_{\text{sys}}) \cdot 10^{-12} \text{ cm}^{-2} \text{ s}^{-1}$  was obtained (Aharonian et al. 2006a). As for the earlier measurements, the  $\gamma$ -ray emission was found point-like and coincident within the errors with the position of Sgr A\*. In 2004 and 2005 the MAGIC collaboration observed HESS J1745-290 and also reported the detection of a point-like, non-variable source (Albert et al. 2006). These measurements confirmed the hard spectrum found by H.E.S.S., with consistent flux levels.

At these days, the differences between the various measurements could either be explained by rapidly varying  $\gamma$ -ray emission from the source (with the caveat that none of the experiments detected significant variability in its own data set), or some hidden systematics in the data analyses. Indeed, after a careful reanalysis of the Whipple data (Kosack 2005) the flux level was corrected, and a differential energy spectrum matching the H.E.S.S. and MAGIC spectra was obtained. Moreover, observations with the CANGAROO-III array recently yielded a differential energy spectrum consistent with the H.E.S.S. and MAGIC results (Mizukami 2008), such that the initial disagreements about the spectral properties of HESS J1745-290 seem to be settled.

An update on the spectrum of the source was recently put forward by the H.E.S.S. collaboration. Based on 93 hours (live time) of observations during the years 2004-2006, a clear deviation of the energy spectrum from a single power-law distribution is observed for the first time. The spectrum is well described by a power-law with exponential cut-off,

$$\frac{dN}{dE} = \Phi_0 \cdot \left( \frac{E}{1\text{TeV}} \right)^{-\Gamma} e^{-\frac{E}{E_c}},$$

with  $\Phi_0 = (2.40 \pm 0.10) \cdot 10^{-12} \text{ TeV}^{-1} \text{ cm}^{-2} \text{ s}^{-1}$ ,  $\Gamma = 2.10 \pm 0.04$ , and  $E_c = (14.70 \pm 3.41) \text{ TeV}$  (Aharonian et al. 2009). A single power-law fit is rejected with a  $\chi^2/\text{dof}$  of 64/27, but the data are equally well described by a smoothed broken power-law (Aharonian et al. 2009). Fig. 2. shows a compilation of the at date available VHE  $\gamma$ -ray flux measurements of HESS J1745-290, together with the above given fit to the latest H.E.S.S. data, indicating the recent agreement between the different instruments.

### 3. HESS J1745-290: a prime example of an unidentified $\gamma$ -ray source

Despite the recent progress in obtaining a consistent picture of the GC VHE emission, the actual mechanism that produces the emission is not yet understood. A firm identification is particularly hampered by the – compared to radio or X-ray instruments – modest angular resolution of the current generation of

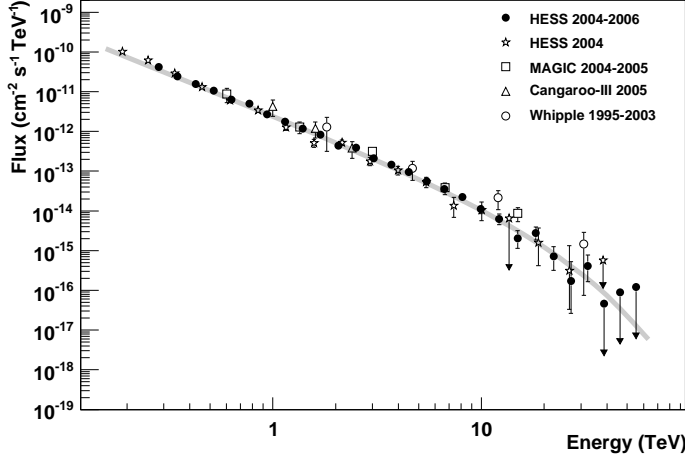


Figure 1. Compilation of VHE  $\gamma$ -ray spectra of the GC source HESS J1745-290. Data points are taken from Kosack (2005), Aharonian et al. (2006a), Albert et al. (2006), Mizukami (2008), and Aharonian et al. (2009). The curve shows a power-law fit with exponential cut-off to the most recent H.E.S.S. data (see text and Aharonian et al. 2009). Note that the H.E.S.S. spectra were corrected for a flux contribution of  $\sim 15\%$  from diffuse emission. Upper limits are given at 95% CL. The early results from Whipple (Kosack et al. 2004) and Cangaroo-II (Tsuchiya et al. 2004) are not shown.

Cherenkov telescopes ( $\leq 5'$  for a single  $\gamma$ -ray at TeV energies). Compared to the projected distances of counterpart candidates in the GC, the VHE emission region is relatively large, giving rise to source confusion in this densely populated part of the Galaxy. Nevertheless can VHE  $\gamma$ -ray observations put constraints on counterparts and emission models in various ways. Without being in conflict with measurements at longer wavelengths, models for HESS J1745-290 must explain the following source properties:

- The energy spectrum between 160 GeV and 70 TeV can be characterised by a power-law with exponential cut-off, or a smoothed broken power-law (see section 2.). The integral flux above 1 TeV is  $2 \cdot 10^{-12} \text{ cm}^{-2} \text{ s}^{-1}$ . This implies a  $\gamma$ -ray luminosity of about  $10^{35} \text{ erg s}^{-1}$  in the 1-10 TeV range.
- There is no hint for significant flux variability on any timescale from minutes to years (Aharonian et al. 2009).
- The centroid of HESS J1745-290 is, within  $8'' \pm 9''_{\text{stat}} \pm 9''_{\text{sys}}$ , coincident with the position of Sgr A\* (Acero et al. 2009), and the intrinsic size of the source amounts to less than 1.2 arc minutes.

Although an association of HESS J1745-290 with Sgr A\* is compelling (and certainly viable in terms of energetics, position and spectrum, see below), there are at least two other objects in direct vicinity of the SMBH which are good candidates for producing the observed  $\gamma$ -ray flux in parts or in total: the SNR Sgr A East and the recently discovered PWN candidate G359.95-0.04.

*The case of Sgr A East* The existence of synchrotron radiation, i.e. the presence of relativistic electrons, and a large magnetic field ( $\approx 2 - 4$  mG, Yusef-Zadeh et al. 1996) make Sgr A East a compelling candidate for  $\gamma$ -ray emission at VHE energies. The energy spectra at radio, X-ray, and soft  $\gamma$ -ray energies match a model in which protons get accelerated in shock waves to an energy of at least 100 GeV (Fatuzzo & Melia 2003). Adopting a 4 mG magnetic field, Crocker et al. (2005) estimate a maximum proton energy of  $10^{19}$  eV achievable in the Sgr A East blast wave. Furthermore, the observed absence of flux variability from HESS J1745-290 is naturally supported by the fact that particle acceleration is supposed to take place in the extended shell of the SNR.

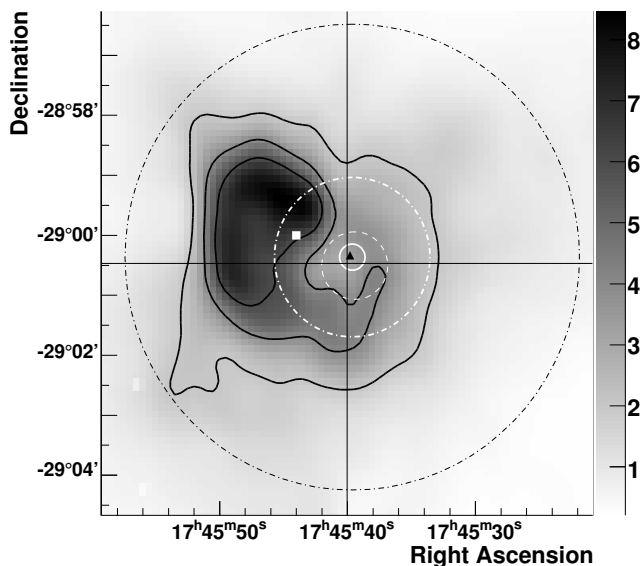


Figure 2. 90 cm VLA radio flux density map (LaRosa et al. 2000) of the innermost 20 pc of the GC, showing emission Sgr A East. Black contours denote radio flux levels of 2, 4, and 6 Jy/beam. The centre of the SNR (Green 2009) is marked by the white square, and the positions of Sgr A Star (Reid et al. 1999) and G395.95-0.04 (head position, Wang et al. 2006) are given by the cross hairs and the black triangle, respectively. The 68% CL total error contour of the best-fit centroid position of HESS J1745-290 is given by the white circle. The dashed white circle shows the same contour for the previously reported H.E.S.S. measurement (Aharonian et al. 2006a). The white and black dashed-dotted lines show the 95% CL upper limit contour of the source extension and the 68% containment region of the H.E.S.S. PSF, respectively.

Sgr A East was, however, recently excluded as the main counterpart of the VHE emission by arguments of the position of the VHE emission centroid (Acero et al. 2009). For illustration, fig. 2 shows a VLA 90 cm image of the innermost 20 pc region of the GC, centred on Sgr A\*. The shell-like radio structure of Sgr A East is clearly visible. It surrounds Sgr A\* in projection, and its radio emission maximum is only  $1.5'$  (or about 3.5 pc) away from the position

of Sgr A\*, well within the point spread function of the H.E.S.S. measurement. The centroid of HESS J1745-290, however, with a 68% CL total error radius of 13" only, is located in a region where the radio emission from Sgr A East is comparatively low. This position measurement is the most precise so far in VHE  $\gamma$ -ray astronomy, and was achieved after a careful investigation of the pointing systematics of the H.E.S.S. telescopes, reducing the systematic error on the centroid position from 20" (Aharonian et al. 2006a) to 6" per axis. Due to such small errors, Sgr A East is ruled out as the bulk emitter of the VHE  $\gamma$ -rays (at a significance of  $3.9 \sigma$  for the most conservative analysis, Acero et al. 2009)).

*HESS J1745-290: a pulsar wind nebula?* The recent detection of the PWN candidate G359.95-0.04 in a deep Chandra exposure of the GC region (Wang et al. 2006) very much complicates the identification of HESS J1745-290. G359.95-0.04 is located only 8.7" in projection (or 0.3 pc) away from Sgr A\*, rendering a discrimination of the two by means of a position measurement of HESS J1745-290 impossible (see. Fig. 2). G359.95-0.04 is rather faint at X-ray energies, with an implied luminosity of  $10^{34}$  erg s $^{-1}$  in the 2-10 keV band (Wang et al. 2006), yet about four times brighter than Sgr A\*. It shows a cometary shape and exhibits a hard and non-thermal spectrum which gradually softens when going away from the "head" of the PWN, where the yet undiscovered pulsar is believed to be located. No radio counterpart of the PWN is found.

Numerical calculations show that a population of non-thermal electrons can naturally explain both the X-ray emission of G359.95-0.04 and the VHE  $\gamma$ -ray emission of HESS J1745-290 (Hinton & Aharonian 2007). Compared to other locations in the galactic disk the GC region is special because of its dense radiation fields. TeV electrons up-scatter predominantly the far-IR component of the radiation field to TeV energies. This provides roughly an order of magnitude larger luminosity in the 1-10 TeV  $\gamma$ -ray band than in the 2-10 keV X-ray domain.

*Gamma-ray emission scenarios involving Sgr A\** Its low bolometric luminosity ( $< 10^{-8} L_{\text{Edd}}$  in the range from millimetre to optical wavelengths) renders Sgr A\* an unusually quiet representative of galactic nuclei. At the same time, this property makes the immediate vicinity of the SMBH transparent to VHE  $\gamma$ -rays. Aharonian & Neronov (2005a) show that the absence of dense IR radiation fields enables photons with an energy of up to several TeV to escape almost unabsorbed from regions as close as several Schwarzschild radii from the centre of the SMBH. Therefore, VHE  $\gamma$ -ray emission produced close to the event horizon of Sgr A\* provides a unique opportunity to study particle acceleration and radiation in the vicinity of a black hole.

Sgr A\* offers several possibilities to produce the observed VHE  $\gamma$ -ray flux, depending on the type of particles accelerated, the model of acceleration, and finally the interaction of the accelerated particles with the ambient magnetic field or matter. Common scenarios, which do not contradict the emission at longer wavelengths, include  $\gamma$ -ray production close to the SMBH itself (Aharonian & Neronov 2005a), within an  $\mathcal{O}(10)$  pc zone around Sgr A\* due to the interaction of run-away protons with the ambient medium (Aharonian & Neronov 2005b; Liu et al. 2006; Wang et al. 2009), or electron acceleration in termination shocks driven by

winds emerging from within a couple of Schwarzschild radii (Atoyan & Dermer 2004).

While some of these models suggest correlated multi-wavelength variability, others predict a steady VHE flux because of diffusion of accelerated particles into the surroundings or acceleration in an extended region far away from the SMBH surface. Therefore, non-observation of variability does not rule out Sgr A\* as a counterpart candidate. On the other hand, the detection of variability in the VHE data would immediately point to  $\gamma$ -ray production in its vicinity. The most convincing signature would be the discovery of correlated flaring in X-rays (or NIR) and VHE  $\gamma$ -rays. Such a search has been carried out (Aharonian et al. 2008). In a coordinated multi-wavelength campaign both Chandra and H.E.S.S. observed the GC region, when a major (factor 9 increase) X-ray outburst was detected. During this 1600 s flare the VHE  $\gamma$ -ray flux stayed constant within errors, and a 99% CL upper limit on a doubling of the VHE flux was derived. When interpreting the X-ray flare as synchrotron emission of TeV electrons, the non-observation of an inverse Compton VHE counterpart implies a magnetic field strength in the emission region of  $> 50$  mG (Aharonian et al. 2008). So far no strong constraint can be derived from these findings, because even larger magnetic fields are expected close to Sgr A\*.

*Dark Matter annihilation close to the GC?* Besides being of astrophysical origin, the observed TeV flux could potentially stem from annihilation of dark-matter (DM) particles, which are believed to cluster in a compact cusp around Sgr A\* (e.g. Bergström 2000). Halo density profiles are believed to scale with the radius  $r$  like  $r^{-\alpha}$ , with  $\alpha$  between 1 (Navarro et al. 1997) and 1.5 (Moore et al. 1999) in the most common models. The fact that HESS J1745-290 is point-like – after having accounted for the underlying diffuse emission – translates into  $\alpha > 1.2$ , i.e. a cuspy halo is favoured by the observations (Aharonian et al. 2006a).

Predicted energy spectra for  $\gamma$ -rays produced in cascade decays of DM particles, such as MSSM neutralinos or Kaluza-Klein particles, can be compared to the VHE observations. These spectra are usually curved both at high energies – for reasons of energy conservation –, and low energies, somewhat in disagreement with the observations (Fig. 2., see also Aharonian et al. 2006a). Furthermore, unusually large DM particle masses have to be assumed to account for the fact that the  $\gamma$ -ray spectrum extends far beyond 10 TeV.

The  $\gamma$ -ray emission from HESS J1745-290 is therefore not compatible with being dominantly produced in the framework of the most common DM scenarios. As a consequence, the bulk of the  $\gamma$ -ray excess is probably of astrophysics rather than of particle physics origin. However, an  $\mathcal{O}(10\%)$  admixture of  $\gamma$ -rays from DM annihilations in the signal cannot be ruled out. Assuming an NFW-type (Navarro et al. 1997) halo profile, 99% CL upper limits on the velocity-weighted annihilation cross section  $\langle \sigma v \rangle$  are at least two orders of magnitude above theoretical expectations, and thus are not able to put constraints on current DM model predictions (Aharonian et al. 2006a).

#### 4. Diffuse $\gamma$ -ray emission: a cosmic ray accelerator at the GC?

The diffuse emission detected by H.E.S.S. covers a region of roughly  $2^\circ$  in galactic longitude ( $l$ ) with an rms width of about  $0.2^\circ$  in galactic latitude ( $b$ ). The reconstructed  $\gamma$ -ray spectrum integrated within  $|l| \leq 0.8$  and  $|b| \leq 0.3$  is well-described by a power law with photon index  $\Gamma = 2.29$  (Aharonian et al. 2006b), similar to what is observed for HESS J1745-290. There is, at least for  $|l| \leq 1^\circ$ , a strong correlation between the morphology of the observed  $\gamma$ -rays and the density of molecular clouds (traced by CS emission, Tsuboi et al. 1999). This is a strong indication for the presence of an accelerator of (hadronic) cosmic rays in the GC region, since the energetic hadrons would interact with the material in the clouds, giving rise to the observed  $\gamma$ -ray flux via  $\pi^0 \rightarrow \gamma\gamma$  decays. The idea of local acceleration is further supported by the fact that the measured  $\gamma$ -ray flux is both larger and harder than expected in a scenario where the molecular material is only bathed in a sea of Galactic cosmic rays of similar properties as measured in our solar neighbourhood. A distribution of electron accelerators, such as PWNe, that cluster similarly to the gas distribution, has also been discussed (e.g. Aharonian et al. 2006b; Wommer et al. 2008). Given the  $\mathcal{O}(100\mu\text{G})$  magnetic fields in the region, electrons of several TeV energy would, however, rapidly cool via synchrotron radiation, such that instead of diffuse emission several point-like VHE  $\gamma$ -ray sources would be expected.

In the context of identifying the accelerator, the fact that no emission is seen farther away than  $|l| \approx 1^\circ$  might be particularly important. A simple, yet convincing explanation is that the cosmic rays were accelerated in a rather young source near the very centre of the galaxy, and underwent diffusion away from the accelerator into the surrounding medium. Assuming a typical diffusion coefficient of  $10^{30} \text{ cm}^2 \text{ s}^{-1}$  (or  $3 \text{ kpc}^2 \text{ Myr}^{-1}$ ) for TeV protons in the Galactic disk, a source age of about  $10^4$  years can reproduce the observed  $\gamma$ -ray morphology (Aharonian et al. 2006b), in particular the lack of emission beyond  $1^\circ$  distance from the centre.

Büsching et al. (2007) follow up on this idea. Starting from a source of non-thermal protons at the GC and the fairly well-known distribution of molecular material, the authors model the  $\gamma$ -ray flux from the region in a time dependent diffusion picture. Neglecting a possible energy dependence of the diffusion process, they compute the diffusion coefficient for which the H.E.S.S. results are matched best, for a variety of source ages and source on-times. In a similar approach, using a more accurate 3d model for the distribution of molecular clouds, Dimitrakoudis et al. (2009) obtain a best-fit diffusion coefficient of  $3 \text{ kpc}^2 \text{ Myr}^{-1}$ , close to what was initially suggested (Aharonian et al. 2006b). Scaling the diffusion coefficient  $k$  with the cosmic ray rigidity  $\zeta$ ,  $k = k_0(\zeta/\zeta_0)^{0.6}$ ,  $\zeta_0 = 1 \text{ GV}/c$ , Büsching et al. find a value of  $k_0$  which is significantly smaller than the local value, suggesting enhanced turbulence and larger magnetic fields than in the solar neighbourhood.

Büsching & de Jager (2008) try to explain both the diffuse emission and the point-source HESS J1745-290 within a single model. The authors assume that the cosmic rays responsible for the diffuse emission were accelerated in the shock wave of Sgr A East 5-10 kyr ago, but acceleration stopped well before the present time. At some point, the shock wave of Sgr A East collided with Sgr A\*, such that particle acceleration near the SMBH was initiated, leading



to the observed VHE  $\gamma$ -ray emission from HESS J1745-290. Assuming that the diffusion coefficient found for the diffuse emission is also valid close to the SMBH, this last round of particle acceleration can only have happened in the recent past ( $\mathcal{O}(100)$  yr) to be consistent with the point-like morphology of HESS J1745-290.

It should, however, be noted that there are other processes which can explain the emission from HESS J1745-290 (see section 3.). Furthermore, recent simulations may indicate that the diffuse emission might be better explained by inter-cloud acceleration of cosmic rays via the Fermi-II process (Wommer et al. 2008). More sensitive observations are needed to ultimately prove which of the discussed scenarios of the VHE  $\gamma$ -ray view of the GC is correct.

## 5. Conclusions

Six years after the discovery of VHE  $\gamma$ -ray emission from the direction of the GC, observations with Imaging Atmospheric Cherenkov Telescopes provide a very sensitive view of this interesting region. With the recent data from the H.E.S.S. instrument, a rich VHE  $\gamma$ -ray morphology becomes evident, giving strong indication for the existence of a cosmic ray accelerator within the central 10 pc of the Milky Way.

A strong  $\gamma$ -ray point source is found coincident with the position of Sgr A\*, within unprecedentedly small errors. Source confusion near the GC make a solid identification still difficult, given the non-observation of variability and the moderate angular resolution of current IACTs. However, the recent progress in improving on the systematic errors of the centroid position of HESS J1745-290 excludes the SNR Sgr A East as the dominant source of the  $\gamma$ -ray emission. A major contribution from the annihilation of DM particles is also excluded, based on the shape of the  $\gamma$ -ray energy spectra.

Future observations with even more sensitive instruments such as CTA will significantly advance our knowledge about the GC region at VHE energies. The recently launched Fermi satellite will extend the energy range down to less than 100 MeV, such that unbroken sensitivity coverage will be provided over 6 orders of magnitude in energy.

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